Introduction to
ANESTHESIA

THE PRINCIPLES OF SAFE PRACTICE

Line Drawings by Dr. Vandam

Fifth Edition

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PREFACE TO THE FIFTH EDITION

Approximately 20 years ago, three anesthesiologists at the University of Pennsylvania resolved to publish a text on anesthesia in the belief that the need was great. The idea was conceived in October of 1956, a first draft was completed at Barnegat Light, New Jersey, one cold week in January, the final manuscript was sent to W. B. Saunders Company in March, and the book was published in September of 1957 at a price of $4.75. Our purpose was fourfold: to offer an introductory text, to write the material as succinctly as possible, to base the message strictly on fact, and to keep the price of the book at a minimum.

In each subsequent edition we have striven to abide by the original intentions. But as the field of anesthesia broadened and the available information expanded, the book inevitably grew larger. We have resisted the pressure to prepare a more comprehensive work. As our respective professional burdens increased, it became increasingly difficult to prepare the material by ourselves; in this, as in the last edition, our associates have helped us beyond measure. However, the text remains our sole responsibility. As will be apparent, there have been both deletions and additions in this latest effort, more than a few chapters have been entirely rewritten, the references have been brought up to date, and the material has been made consistent with current practice.

No one of us has been solely responsible for the original edition or any of the revisions, always a product of all three. If an impasse was reached, R. D. Dripps, by agreement as senior, had the last word. But seldom was he prompted to take a stance. We edited each others' chapters with vigor—even at times tore them apart! Little passed unchallenged. As a result, a rare synthesis of ideas was achieved.

Upon Bob Dripps' untimely and lamentable death in October of 1973, we were unsure of the wisdom of approaching a fifth edition. However, we were persuaded to do so by many friends, who thought that neglect of the task might constitute a disservice to anesthesiology. Hence we present a fifth edition, still under the authorship and style of Dripps, Eckenhoff, and Vandam. The first edition was dedicated to a dear surgeon friend, I. S. Ravdin. Dedications are usually not altered in subsequent editions, but we dare to break with tradition and dedicate the fifth to the memory of Robert Dunning Dripps, to whom both of us and all of medicine owe so much.

James Eckenhoff and Leroy Vandam are uncertain if there will be another edition to appear under their coauthorship. If still active in practice, we may well try again. Otherwise, if the hope is not realized, we trust that those whom we have taught and counseled will continue to work at the goal where we have left off—that of an introductory text, succinctly written, based on fact, and modestly priced.

JAMES E. ECKENHOFF
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PREFACE TO THE FIRST EDITION

This book is a descendant of a smaller work privately printed in 1949 and circulated in the Department of Anesthesiology of the Hospital of the University of Pennsylvania. It was called "Organization and Procedures." A second and larger edition appeared in 1953. The third lineal descendant is now being made available to others.

Much of the teaching of anesthesia is by word of mouth. Beginners seek to learn countless details that cannot be found in general texts. This is the lore of anesthesia that must be passed on from individual to individual. A good bit of the material gathered in this volume might be classified as being in this rather shadowy area, including such topics as the philosophy of records, surgeon-anesthetist relations, the value of death reports, hazards of the immediate postoperative period, the treatment of immediate postoperative pain and excitement, and the determination of the depth of general anesthesia.

The subjects and the manner of their presentation represent the thinking and ultimate distillation into teaching practice of the senior staff at Pennsylvania, augmented and refined by all who came within teaching range. One who contributed much to the early editions and whose influence may be discerned in the present volume is Austin Lamont. We mention him with respect and give thanks to others who will find bits of their practice and philosophy in print.

Chapters dealing with fundamental aspects of certain techniques and with basic considerations of the drugs used in anesthesia have been included in the hope that such material can contribute to the safer practice of anesthesia. These are guides; they contain what we believe to be established precepts, but they are not covered in detail nor can they be regarded as complete.

We have intentionally omitted discussion of most of the specialized aspects of anesthesia such as hypothermia, deliberate hypotension, hypnosis, the technical considerations of regional anesthesia, and problems of the treatment of pain. These constitute advanced study in the field. We believe that the students for whom this book is intended should not be confronted by them until later in their training.

We trust that this book will be instructive for all students of anesthesia and those in other fields who would learn a little something of this specialty. We hope that it may be a useful introductory volume of interest before one proceeds to wider reading. Although we have listed only a few references as guides for further study, it has not been our intention to slight individuals who have made important contributions. Doubtless, omissions and reasons for disagreement will be found.

Dr. Henry L. Price, Dr. Ronald Woolmer and others of our associates have contributed valuable suggestions. Miss Sally Van de Water has performed yeoman service as our secretarial assistant. We acknowledge these contributions with gratitude.

Robert D. Dripps
James E. Eckenhoff
Leroy D. Vandam

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Chapter 1

THE BROAD REALM OF ANESTHESIOLOGY

Anesthesia is recognized as a major American contribution to medicine. News of the first successful demonstration of ether in Boston, in 1846, spread rapidly to Europe where leading surgeons were quick to try this remarkable substance. Within a year another general anesthetic, chloroform, was used in England, and the introduction of the two agents set the stage for the development of the specialty of anesthesia in the two countries. Chloroform was introduced by an eminent obstetrician, James Y. Simpson. It was both a respiratory and circulatory depressant, requiring great skill in administration and lethal in unskilled hands. A large number of deaths attested to the potency of chloroform; therefore only physicians were judged competent to administer it.

In the United States, dentist William T. G. Morton, who had publicly introduced ether, was challenged for the priority by his collaborator, scientist Charles Jackson, by dentist Horace Wells who earlier introduced nitrous oxide, and finally by physician Crawford W. Long, who had first given ether in 1842 but without audience or publication. The attempts at establishing patents and the controversy over who should receive recognition for its discovery placed anesthesia under a cloud. In contrast to chloroform, ether stimulated both respiration and circulation, which was thought to be a built-in protection for the patient and the reason why a skilled person did not have to administer it. Students, nurses, newly graduated physicians, specialists in other fields, and even custodians were called upon to be "etherizers." When toward the end of the century nurses were encouraged to become full-time anesthetists, patients received better care because someone with continuing experience was anesthetizing them.

Some 60 years elapsed before the first American physician began to devote full time to anesthesia. While the strides made by surgery around the turn of the century were great, little change occurred in anesthesia, even though some surgeons pleaded for anesthesia specialists. Two separate series of events sparked the development of anesthesia as a discipline. The first comprised two world wars, which created a need for large numbers of anesthetists to care for battle casualties. The second was the increasingly complex nature of operations, which produced a demand for

more skilled help. In 1931 there were enough specialists on hand to form the American Society of Anesthetists, and in 1937 the American Board of Anesthesiologists began to certify specialists. New agents and equipment appeared, and the older agents were studied anew in the laboratory and clinic. Training programs arose throughout the country, the better ones attracting many trainees at the conclusion of World War II. The introduction of curare, with the accompanying need for control of pulmonary ventilation during and after operations, and the organization of postanesthesia recovery rooms provided further breadth for the fledgling specialty. By 1950 anesthesiologists' activities began to spread beyond the confines of the operating room.

For more than 100 years after the introduction of ether surgeons had dominated the operating room, everyone bowing to their authority. This dominance now began to wane. Operating teams evolved consisting of several surgeons, anesthetists, and highly competent nurses. The development of new agents, adjuvants, equipment, and techniques had changed anesthesia into a discipline now beyond the training of surgeons who had formerly supervised technicians or had given the anesthetics themselves. Therefore most surgeons readily welcomed physician anesthetists as full partners in the surgical team.

Over the past two decades, anesthesiology has emerged as a clearly defined specialty recognized and respected throughout the country. In every medical school anesthesiology functions mostly as an autonomous academic department, in some as a division of surgery. There are approximately 2300 physicians in training in 164 anesthesiology residency programs in the United States. The American Board of Anesthesiologists to date has certified over 8000 specialists, and the Board has been recognized as a leader among specialty boards in setting standards and improving techniques of examination. Approximately 4.5 per cent of all physicians practicing in the United States are anesthesiologists. There are more than a few national societies and an impressive number of journals and texts is published each year on the subject.

NURSE ANESTHETISTS AND ANESTHESIOLOGISTS

About one half of the 20 million anesthetics given annually in the United States are administered by nonphysicians. Thus the public is confused as to the difference between a nurse anesthetist and an anesthesiologist. To become certified as a registered nurse anesthetist (CRNA) the nurse must have a high school education, an average of three years of nursing training, plus two additional years of anesthesia training followed by an examination. To become an anesthesiologist, after college and award of the medical degree a physician must have four years of postgraduate training in an approved residency program, with one year devoted to medicine, surgery, or other clinical discipline. Two years are spent in clinical anesthe-

sia and the optional fourth in a specialized area of choice. Some engage in practice for two years in lieu of the optional fourth year. Those qualified take an examination to become diplomates of the American Board of Anesthesiology. In the United States, neither a nurse nor a physician has to pass certification to practice anesthesiology, nor indeed, any other specialty. It is possible to administer anesthesia without formal training if a hospital will accept the lack of credentials!

It is apparent that the physician anesthesiologist offers greater depth of training than the nurse anesthetist, but this does not necessarily qualify the physician as a better anesthetist. By achieving the technical skills and the appropriate experience and knowledge, a conscientious nurse can easily surmount the gap in training. An anesthesiologist, acting as a technician, who fails to keep abreast of advances in medicine soon loses the advantage.

In general, the CRNA is an employee of a hospital; a few practice on a fee-for-service basis, as do most anesthesiologists. Their malpractice liability is less than that of physicians (see Chapter 5). For the most part their activities are confined to the operating room; they often do not participate in pre- or postoperative care and are not in a position by virtue of their background to exercise medical judgment. In the eyes of the law they function under the medical direction of physicians, either the surgeon or an anesthesiologist.

In most large hospital departments nurse and physician anesthetists and technicians work in harmony. Cases are assigned by physicians who evaluate the patients preoperatively, write preoperative notes and preanesthetic orders, assist as necessary during anesthesia, remain available for consultation, and care for patients postoperatively in the event of complications. Considering the extensive national demands for anesthesia care it is unlikely that all anesthetics will ever be given solely by physicians. As paralleled by the trend toward midwifery in obstetrics, there is and always will be a need for nurse anesthetists.

FUNCTIONS OF THE ANESTHESIOLOGIST

The principal tasks of the anesthesiologist are to provide relief from pain for patients during operation and optimal operative conditions for surgeons, both in the safest possible manner. To do this the anesthesiologist must be a competent physician and a clinical pharmacologist, with a broad knowledge of surgery and the ability to utilize and interpret correctly a variety of monitoring devices.

In addition to anesthetics, drugs employed by anesthesiologists include: opioids and antagonists, antisialagogues, barbiturates, tranquilizers, vasopressors, vasodilators, antiarrhythmics, cardiotonics, antihypertensives, neuromuscular blockers and antagonists, analeptics and steroids—to cite just a few. In recent years the interaction of drugs and their pathways of elimination have assumed increasing importance, not only from the

viewpoint of widespread drug usage by patients but also because inhalation anesthetics, once thought inert, are now known to undergo metabolic transformation, interacting with other drugs and body components.

Anesthetists must combine a knowledge of the patient's disease, the drugs taken, the demands of the operation, and the patient's concerns in order to arrive at a proper choice of agent and technique. Most monitoring devices in use in intensive care units today are modifications and extensions of equipment first used by anesthetists in operating suites. Recovery rooms arose out of the need for continued individual patient care, and today both surgical and medical intensive care units extend such attention to all critically ill patients. Blood pressure via direct or indirect recording, heart and breath sounds, blood gas analysis, central venous pressure, body temperature, and pulmonary wedge pressure commonly are measured during anesthesia and an electrocardiogram and an electroencephalogram taken.

Fluid replacement during operation is supervised by the anesthetist, who establishes the routes of administration and the kinds of fluids given while keeping track of blood loss and therefore determining blood or blood component therapy needed. In this sphere, consultation between surgeon and anesthetist is essential.

Anesthetists spend more time in the operating room than any other group of physicians. It is logical, therefore, that many institutions have appointed an anesthesiologist chief of the operating room, responsible for day to day scheduling and overall supervision of activities.

In the United States, prior to the introduction of curare, the principal anesthetic used was ether. Because of its stimulant effect on respiration, control of ventilation was of little importance. Cyclopropane depressed respiration in light planes of anesthesia, allowing for easier control of respiration, but failed to provide good abdominal relaxation. Curare altered all of this; with muscle relaxation came respiratory paralysis. Not only was the patient unconscious but unable to breathe as well. By necessity, anesthetists became respiratory physiologists and experts at managing ventilatory inadequacy. New ventilators were devised, monitoring equipment was introduced to ensure ventilatory exchange, and blood gas analysis was perfected. Again, such expertise could not be restricted to the operating room. Anesthetists began to be consulted in intensive care and respiratory care units, in the care of traumatized patients and those with neurologic deficits. In many hospitals today, anesthesiologists manage respiratory and inhalation therapy services; an appreciable number are solely involved in these endeavors (see Chapters 32 and 33).

SPECIALIZED ANESTHESIA SERVICES

Some anesthetists allied with general surgical services have found the field too broad and have preferred to specialize. While a few have elected